27

PRELIMINARY HAZARD AND RISK

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27 Preliminary Hazard and Risk

27.1 Overview

This chapter of the EIS describes the potential hazards and risk to people and property that may be associated with the Project, as distinct from hazards and risk to the natural environment which are addressed in other chapters of the EIS. Hazards and risks involving noise and vibration, air emissions and social impact are covered in other chapters of the EIS.

The scope for this assessment includes:

- Project hazards with the potential for injury or harm to the public;
- Project hazards with the potential for damage to public property;
- Natural events as an initiating event resulting in injury or harm to Arrow employees or contractors; and
- Natural events as an initiating event resulting in injury or harm to the public due to the Project.

The main technical appendix supporting the assessment is the Preliminary Hazard and Risk Technical Report (Appendix Y of this EIS). This preliminary hazard analysis (PHA) includes a quantitative risk analysis that estimates and assesses the risk at offsite land uses. A cross reference to the locations where each of the requirements of the ToR has been addressed is given in Appendix B which references both the study chapters (Sections 1 through 34) and/or the Appendices (A through EE).

The main findings of this chapter are:

- Natural hazards present a potential risk to people and assets associated with the Project sites. This risk is minimised by selection of sites associated with the Project to avoid natural hazards, particularly flood risk, bushfire risk and landslide risk.
- Accident events involving loss of containment at the Project sites have the potential to result in harm to people or property in the vicinity of the sites. The risk calculated in the PHA has been used to determine preliminary separation distances to different land use types from the facilities and pipelines to ensure that risk acceptability criteria are met.

Arrow's integrated risk management plan covers the lifecycle of the Project and ensures that hazard and risk to people and property is systematically managed to a level that is as low as reasonably practicable (ALARP)[1].

27.2 Values Related to People and Property

Values related to people and property are described in the Landuse and Tenure chapter (Section 19) of this EIS and in summary comprise:

- Health and wellbeing;
- Land uses;
  - agriculture;

[1] The ALARP principle is that the residual risk shall be as low as reasonably practicable. For a risk to be ALARP it must be possible to demonstrate that the cost involved in reducing the risk further would be grossly disproportionate to the benefit gained.

  - urban development;
  - mining and resources; and
  - conservation tourism.
- Infrastructure including:
  - roads;
  - airports
  - rail;
  - stock routes; and
  - utilities and other services.

The predominant land use within the Project area is agricultural activities, mainly grazing. This includes homesteads that are located over larger pastoral allotments within the Project area.

Risks have been assessed in terms of the potential to harm people or property. This includes assessment against the quantitative criteria of the NSW Department of Planning's *Hazardous Industry Planning Advisory Papers* (HIPAP) No.4 (DoP, 2011a).

27.3 Legislation, Codes and Standards

27.3.1 Legislation

Legislation relevant to the identification and control of hazards and relevant to assessment of risk to people and property are described below.

27.3.1.1 Environmental Protection Act 1994 (Qld)

The objective of the *Environmental Protection Act 1994* (EP Act) is to protect Queensland's environment by promoting ecologically sustainable development. By definition in the Act, the environment includes people and therefore is relevant to hazard and risk. The EP Act monitors the storage and handling of dangerous chemicals on site and the potential risks to human health and the environment.

27.3.1.2 Petroleum and Gas (Production and Safety) Act 2004 (Qld)

The *Petroleum and Gas (Production and Safety) Act 2004* (P&G Act) regulates the natural gas and petroleum industry, including CSG, in Queensland. The aim of the Act is to facilitate and regulate responsible petroleum activities and the expansion of the industry in a safe, efficient and viable manner. The Act aims to minimise land-use conflicts and encourage responsible land-use management.

27.3.1.3 Petroleum and Gas (Production and Safety) Regulation 2004 (Qld)

The *Petroleum and Gas (Production and Safety) Regulation 2004* sets the requirements for safe operations of petroleum installations under the P&G Act, as well as the obligations of operators. Under

the P&G Act, operators of an operating plant are obligated to prepare and submit a suitable safety management plan (SMP) that is appropriate to the level of the plant.

27.3.1.4 Work Health and Safety Act 2011 (Qld)

The *Work Health and Safety Act 2011* aims to secure the health and safety of workers and workplaces including through the elimination or minimisation or risks and by providing the highest level of protection from hazards and risks as is reasonably practicable. Under the Act, employers are required to ensure that the work health and safety of each of their workers and other persons (including members of the public) is not affected by the conduct of the employer's business or undertaking.

27.3.1.5 Electrical Safety Act 2002 (Qld)

The *Electrical Safety Act 2002* establishes a legislative framework for electrical safety in Queensland to prevent injury or fatality to people and the destruction or damage to property from electricity. The principles of the *Electrical Safety Act 2012* are applicable when electrical works are conducted under the *Petroleum and Gas (Production and Safety) Regulation 2004* (Qld).

27.3.1.6 Electricity Act 1994 (Qld)

Under the *Electricity Act 1994* the transmission authority must ensure that access and connection to a grid can be conducted safely.

27.3.1.7 Queensland State Planning Policy 1/03 Mitigating the Adverse Impacts of Flood, Bushfire and Landslide

The Queensland State Planning Policy 1/03 (SPP 1/03) *Mitigating the Adverse Impacts of Flood, Bushfire and Landslide,* which applies to parts of the Project, aims to ensure that the natural hazards of flood, bushfire and landslide are adequately considered when making decisions about certain developments. The aim is to minimise the adverse impacts from these natural hazards on people, property, economic activity, and the environment.

27.3.2 Codes and Standards

The main codes and standards relevant to the identification and control of hazards and relevant to assessment of risk to people and property are described below. Many other standards will be used by the Project to ensure safe design and operations; these are not listed.

27.3.2.1 Safe Work Australia – Model Codes of Practice

New national codes of practice have been developed as part of the harmonised work health and safety laws and have been or are being adopted by the Queensland government. These will supplement Arrow's own procedures on work practices and occupational health and safety.

27.3.2.2 APIA – Code of Practice, Upstream PE Gathering Networks – CSG Industry

This code of practice is a preferred standard under the *Petroleum and Gas (Production and Safety) Regulation 2004*. It provides guidance to industry for the best techniques and methods for working with polyethylene pipe and fittings in the CSG industry. Its approach to risk assessment reflects the approach in AS 2885.1–2007.

27.3.2.3 NSW Department of Planning – Hazardous Industry Planning Advisory Papers

These are used for potentially hazardous onshore developments in NSW and elsewhere (including Queensland) as required by authorities or as suitable industry guidelines. They include risk criteria and risk assessment techniques to be used when assessing the locational and technical safety aspects of a development.

27.3.2.4 AS 2885 – Pipelines – Gas and Liquid Petroleum

The AS 2885 series of Standards establishes requirements for the safe design, construction, inspection, testing, operation and maintenance of pipelines. Although the scope is generally high pressure steel petroleum pipelines, they can be applied to other services and materials. Their requirements ensure the protection of the general public, the operating personnel, and the environment, as well as the protection of the pipeline against accidental damage.

27.3.2.5 AS 31000:2009 – Risk Management

This standard provides principles and generic guidelines on risk management and is not industry or sector specific. Its framework is reflected in Arrow's own risk management procedures.

27.3.2.6 NSW Department of Infrastructure, Planning and Natural Resources – Locational Guidelines – Development in the Vicinity of Operating Coal Seam Methane Wells

These provide guidelines for assessing development applications for residential and sensitive land uses in the vicinity of CSG wells. Their requirements have been adopted for the Project.

27.3.2.7 Queensland Department of Natural Resources and Mines – SafeOP for Petroleum and Gas – A Guide to Legislative Requirements for Operating Plant

This document provides guidance for the matters to include in a SMP to ensure that it complies with the P&G Act.

27.3.2.8 Queensland Department of Employment, Economic Development and Innovation – Code of Practice for Constructing and Abandoning Coal Seam Gas Wells in Queensland

This code of practice gives minimum mandatory requirements for the design and construction of CSG wells to ensure well integrity from construction through to abandonment. It also provides good industry practice over and above the mandatory requirements and provides further detail than contained in the Acts and Regulations.

27.3.2.9 Queensland Department of Employment, Economic Development and Innovation – Code of Practice for Coal Seam Gas Well Head Emissions Detection and Reporting

This code of practice provides a consistent best practice minimum standard for identifying, classifying, rectifying and reporting well head gas emissions. This enables the gas safety regulator to be appropriately informed and the CSG industry's performance on gas emission management is to be appropriately measured.

27.4 Hazard Identification and Controls

27.4.1 Natural Hazards

Table 27–1 provides an overview of the natural hazards and their controls.

Table 27-1 Overview of Natural Hazards, Potential Impacts and Controls

Hazard	Potential Impact	Controls
Wildlife	• Injury or fatality to Project workers	• Arrow procedures
Bushfire	• Injury to Project workers • Damage to above ground facilities	• SPP 1/03 • Site Locations • Design and Construction standards
Flooding	• Injury to Project workers • Damage to electrical equipment • Floating of pipelines • Site subsidence and damage	• SPP 1/03 • Site Locations • AS 2885.1 requirements for pipelines in floodplains
Landslide	• Damage to above ground facilities • Scouring of pipelines	• SPP 1/03 • Site Locations
Strong wind	• Damage to above ground facilities	• Design and construction standards
Earthquake	• Damage to above ground facilities • Pipeline distortion or failure	• Design and construction standards

Hazard	Potential Impact	Controls
Lightning	• Injury or fatality to Project workers • Pipeline to pipeline or its coating • Damage to above ground facilities	• Arrow procedures • Design and construction standards

Wildlife hazards in the Project area include venomous snakes, spiders, disease vectors and ticks. The Terrestrial Ecology Technical Report (Appendix P of this EIS) includes an indicative list of snakes in the Project area. The dengue mosquito, which lives in the Project area, usually does not carry the dengue virus and will only become infected after biting an infected human. The dengue mosquito prefers to live around domestic settings and does not breed in swamps.

Arrow will train relevant personnel in the identification and avoidance of potentially hazardous wildlife and will use qualified handlers to move wildlife from Project areas when encountered [B543].

Natural hazards to people working on the Project include bushfires, floods, landslide, storms and dust storms.

Bushfire risk in the Project area is mostly classified as Low and Medium risk according to the *Queensland Bushfire Risk Analysis* (Figure 27–1). The three variables on which the bushfire risk analysis was prepared are slope, aspect and vegetation. Compression facilities for the Project will be located on levelled land and where possible, in regions of low bushfire risk. Fire breaks and fuel management around above ground facilities and power poles will be included where necessary to manage bushfire risk [B544]. Therefore the fire risk to workers and facilities will be managed to a low level.

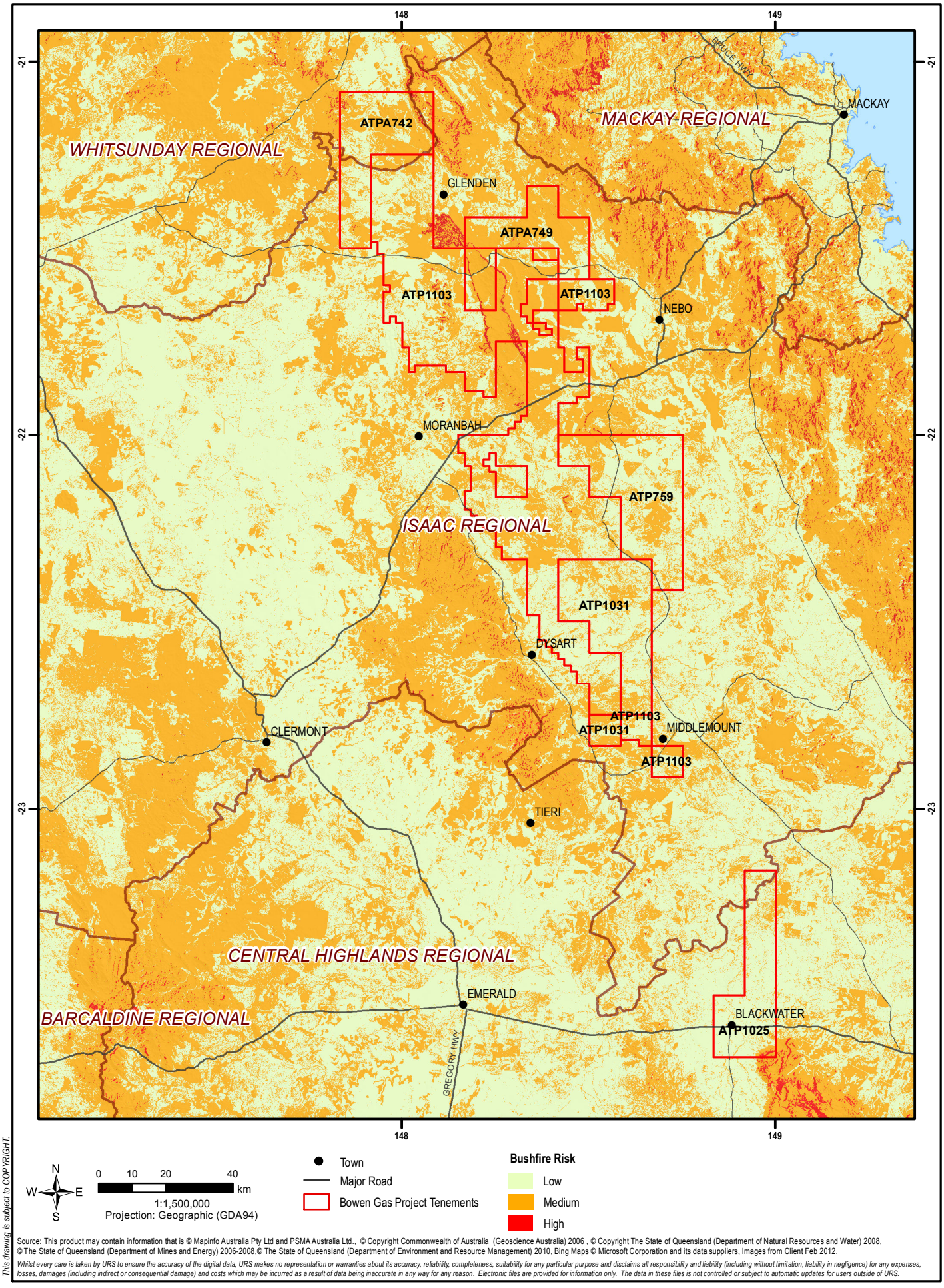
The Project area spans the floodplains of the Bowen, Suttor, Isaac and Mackenzie Rivers' sub-basins. In order to manage risk to the facilities, the sites will be built up and the locations chosen to reduce the risk of damage due to flooding [B489]. Equipment will be installed 0.5 m above the 1 in 50 year flood level, with critical equipment and instrumentation for startup installed 1 m above the 1 in 50 year flood level.

Sites for compression facilities will be located on level ground to minimise landslide risk.

The SPP 1/03 Mitigating the Adverse Impacts of Flood, Bushfire and Landslide applies for flood to all areas of the Project. For bushfire and landslide, SPP 1/03 applies only in some local government areas of the Project. The principals of SPP 1/03 will be applied by the Project on a consistent basis across the Project area to minimise the potential adverse impacts of flood, bushfire and landslide.

Design for credible natural events is managed by Arrow's Health, Safety and Environment Management System (HSEMS) (refer to Section 27.6.2).

Wellheads and compression facilities will have remote isolation. Compression facilities can be shutdown and depressured if required during a flood, bushfire or other natural hazard [B478].



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BOWEN GAS PROJECT EIS

BUSHFIRE RISK

URS

PRELIMINARY HAZARD AND RISK ASSESSMENT

Figure: **27-1**

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27.4.2 Man-Made Hazards

As part of the PHA, potential hazards to the public and their property from activities associated with the Project were identified systematically. This included a workshop comprising a multi-disciplinary team, and a review of similar facilities and historical incidents. Hazard identification tables were prepared for the following phases of the Project:

- Design and installation;
- Operation and maintenance; and
- Decommissioning.

The tables are included in the Preliminary Hazard and Risk Technical Report (Appendix Y of this EIS). The tables record the potential causes and consequences from realisation of the hazards and the required controls to mitigate the risk. The required controls will be implemented for the Project. The tables include an initial assessment of whether events could impact offsite and therefore affect members of the public or their property.

Hazards with the potential for offsite impact were assessed using a risk matrix that consisted of five risk rankings ranging from *Very low* to *Very high*. These hazards are summarised in Table 27–2. There were no *Very high* risk hazards identified. The only *High* risk events were associated with driving, particularly during the installation phase where vehicle traffic is highest. This risk is recognised within the industry and by Arrow who will include many hardware and procedural controls to manage this risk to employees and the public, which they already apply to existing operations in Queensland including [B500]:

- Traffic studies and application of company specifications for road design;
- Communication and agreement with landholders, local councils and easement holders to ensure public roads and access tracks are fit for purpose;
- In-vehicle monitoring system [B472];
- Journey management centre which logs lone work activities; and
- Driver training for staff and contractors and use of APPEA standard for light vehicles and four wheel drive (4WD) vehicles.

Table 27-2 Hazards with Offsite Impact by Risk Rating

Risk	Description of Hazard
Very high	-
High	Transport accidents
Medium	• Communication to water source during hydraulic stimulation of a seam; • Communication to water source during production; • Risk of person falling into empty dam; • Proximity to mine sites – subsidence or blasting activities causes damage to well and gas escape to surface; • Contamination of ground water supplies from loss of containment of feed water or brine • Fire or explosion at facility; • Grass / brush fire (ignition due to vehicle access); and • Failure during pressure testing of pipelines.

Risk	Description of Hazard
Low	• Uncontrolled release of water due to erosion; • Ingress of air into process piping during maintenance or commissioning causing internal fire / explosion; • Failure in depressuring, purging and decontamination during decommissioning leads to fire / explosion; • Injury due to electrocution to the public (power lines, facilities equipment); • Safety risk from holes, ditches, uneven terrain caused by heavy vehicles; • Ongoing subsidence of trench profile – hazard to vehicles; and • Fire exerted from flaring activity (if flare installed rather than cold vent).

Medium risk hazards with offsite impact are typically those involving loss of containment to the atmosphere of flammable CSG or pressure test fluid. If a release of CSG finds an ignition source, then people and property could be at risk of injury from fire. While pressure test fluids are non-flammable, a high pressure discharge from failure in an underground pipeline can lead to expulsion of earth at high velocity. Measures for testing will include pre-testing sections of pipelines offsite and notifications and fencing around high risk areas.

The risk of loss of containment from process equipment and pipelines will be managed through Arrow's Asset Integrity and Process Safety framework [B466]. This framework is a structured approach for management of process hazards from their identification, through to the identification and management of barriers, operations integrity and process safety culture. The framework and associated Arrow HSEMS are described below in Section 27.6. Controls for loss of containment will include:

- Pressure testing of equipment [B502];
- Maintenance and inspection of facilities and pipelines at defined intervals;
- Design of pipes and vessels to maximum pressure [B481];
- Control of ignition sources; and
- Emergency Isolation valves [B504].

Additional controls and barriers will be developed as part of the risk management process during design.

Three hazards in water treatment were classified as *Medium* risk:

- Falling into dam;
- Loss of containment from dam to offsite affecting people or groundwater; and
- Loss of containment from chemical storage or use affecting people or groundwater.

The design, construction and operation of regulated dams will be highly regulated through the use of standards and monitoring requirements which manage the risk associated with loss of containment to a low level [B467]. Fences and escape facilities will be installed to prevent access and harm to people or livestock [B470].

27.4.3 Dangerous Goods Held Onsite

The typical Dangerous Goods and their quantities to be held in the different phases and locations are listed in Table 27–3. A complete list of Dangerous Goods to be held cannot be prepared at this time; however, the table includes all forecast bulk quantities of Dangerous Goods. Smaller quantities of aerosol cans will be held at various sites. These aerosols, which are Dangerous Goods Class 2 typically, include cleaners, disinfectants, battery terminal protector and insect repellents. During construction, chemicals will be transported and held onsite in quantities that exceed the usage at an individual site.

The CSG (predominantly methane), which is processed rather than stored has not been listed in the table. The Waste Management chapter (Section 28) of this EIS contains a more complete list of chemicals including Dangerous Goods and non-Dangerous Goods.

Apart from nitrogen which may be used for purging, the Dangerous Goods are stored at ambient pressure or consist of packaged aerosols and therefore any loss of containment of the Dangerous Goods would have localised impact.

Table 27-3 Forecast Quantities of Dangerous Goods Held Onsite

Hazardous Materials Product Name (Correct Shipping Name)	DG Class and Packaging Group	HazChem / UN Number	Forecasted Quantity Held Onsite
Design and Construction			
Well Sites			
Tolcide PS575 biocide (Toxic liquid, organic not otherwise specified)	6.1 PG III	2X / 2810	1,000 litres
Acetic acid 60% buffer	8 PG II	2P / 2790	5,000 litres
Caustic soda 50% buffer (Sodium hydroxide)	8 PG II	2R / 1823	4,000 litres
Alclean 5032 (Corrosive Liquids N.O.S. (Phosphoric Acid))	8 PG III	2X / 1760	200 kg
Squirts (Aerosol) Range (Aerosols)	2	2YE / 1950	< 10kg
Pine-o-Clean Glen 20 Surface Spray Disinfectant Aerosol (Aerosols)	2	2Y / 1950	< 3kg
Various paints, solvents and thinners	3	2YE or 3YE / various	< 100 litres / kg
Gathering Systems			
Various resins and adhesives	3	3Y	100 litres / kg
Various paints, solvents, thinners	3	2YE or 3YE / various	< 100 litres / kg
Field Compression Facilities (FCFs)			
Battery Terminal Protector (Aerosols)	2	2Y / 1950	13.5 litres

Hazardous Materials Product Name (Correct Shipping Name)	DG Class and Packaging Group	HazChem / UN Number	Forecasted Quantity Held Onsite
Various paints, solvents, thinners	3	2YE or 3YE / various	< 100 litres / kg
Central Gas Processing Facility (CGPF)			
Battery Terminal Protector (Aerosols)	2	2Y / 1950	13.5 litres
Various paints, solvents, thinners	3	2YE or 3YE / various	< 100 litres / kg
Mortein Lure and Kill High Performance Surface Spray Aerosol (Aerosols)	2	2Y / 1950	< 3kg
Integrated Processing Facilities (IPFs)			
Dangerous Goods at the IPFs include those in use at the CGPF.			
Operation			
Well Sites			
Bulk Dangerous Goods not required for the operation of the well sites.			
Gathering Systems			
Bulk Dangerous Goods not required for the operation of the gathering system.			
FCFs			
Various paints, solvents, thinners	3	2YE or 3YE / various	< 100 litres / kg
CGPF			
Various paints, solvents, thinners	3	2YE or 3YE / various	< 100 litres / kg
Mortein Lure and Kill High Performance Surface Spray Aerosol (Aerosols)	2	2Y / 1950	< 3kg
IPF			
Various paints, solvents, thinners	3	2YE or 3YE / various	< 100 litres / kg
Mortein Lure and Kill High Performance Surface Spray Aerosol (Aerosols)	2	2Y / 1950	< 3kg
Sodium hypochlorite	8	2X/1791	60 kL
Sulphuric acid	8 PG II	2P/1830	60 kL
Caustic soda	8	2R/1824	60 kL
Antiscalant		TBA	60 kL
Hydrochloric acid	8	2R/1789	60 kL

Hazardous Materials Product Name (Correct Shipping Name)	DG Class and Packaging Group	HazChem / UN Number	Forecasted Quantity Held Onsite
Ammonium bifluoride	8 PG II	2X/1727	60 kL
Decommissioning			
Wells			
It is envisaged that bulk Dangerous Goods will not be required during decommissioning.			
Gathering Systems			
Nitrogen for purging	2.2	2T / 1066	bulk
FCF, CGPF and IPF			
Nitrogen for purging	2.2	2T / 1066	bulk

27.5 Preliminary Hazard Analysis

27.5.1 Introduction

A PHA was undertaken for the Project facilities and infrastructure to assess the technical safety and locational aspects of the Project with regard to risk to people and property. A PHA is one of the studies required under the NSW Department of Planning's assessment process for potentially hazardous developments. It is undertaken to support a development application by demonstrating that risk levels do not preclude approval. The department has produced guidelines in the form of HIPAP to assist stakeholders in the assessment process. The HIPAP guidelines are the most commonly applied guidelines for land use safety planning in Queensland in the absence of state specific guidelines. The PHA is presented in the Preliminary Hazard and Risk Technical Report (Appendix Y) of this EIS.

The basic process for the PHA was:

- Establish the context, including methodology of assessment and the relevant risk tolerability criteria;
- Perform hazard identification study to identify hazards and their controls throughout all development phases;
- Qualitatively assess the risks during all Project phases using a risk matrix;
- Identify credible scenarios for carrying forward for quantification of consequences and likelihood in the operations phase;
- Consequence analysis for the identified credible scenarios. Where offsite impact was found to have the potential to occur, carry the scenario forward for frequency analysis;
- Frequency analysis to estimate the likelihood of hazardous events for the scenarios with the potential for offsite impact;

- Quantitative risk assessment by combining the offsite scenario consequences and their associated frequency in order to generate risk contours for the development; and
- Assess the offsite risk profile against the risk tolerability criteria and develop appropriate separation distances for development.

A PHA is performed at an early stage of a project, typically with information that is not final, and therefore conservative assumptions are made. For this development, detailed information on site layouts, equipment and safeguards was not available and therefore the study should be considered as preliminary. The PHA is part of the hazard and risk management process that continues through design, installation, operations and decommissioning. The risk assessment will be reviewed and updated as necessary as part of the risk management process to ensure the final design meets risk criteria.

27.5.2 Methodology

The PHA followed the methodology in HIPAP No. 6 *Hazard Analysis* (DoP, 2011b) with risk assessed against the criteria in HIPAP No. 4, *Risk Criteria for Land Use Safety Planning* (DoP, 2011a). A probabilistic risk analysis was undertaken for the operations phase of the Project. Within the scope of hazard and risk, loss of containment of CSG and subsequent ignition is the main hazardous incident which can affect locational aspects or land use planning for facilities and pipelines in the operations phase.

The consequences of loss of containment of CSG from pipelines and facilities were modelled for a range of event sizes and under various representative weather conditions. The likelihood of loss of containment and subsequent ignition of individual scenarios was estimated using historical data appropriate for the type of equipment, and for the location of the facilities and pipelines. The consequence and frequency were mathematically combined in a risk model to produce risk contours and transects for facilities and pipelines respectively. These were assessed against the risk criteria to obtain minimum separation distances to specific land uses.

27.5.3 Hazard Identification

CSG is mostly methane which is a flammable gas and simple asphyxiant. An ignited CSG release from equipment and pipework could result in:

- Jet fire, if ignited immediately;
- Flash fire, if ignition is delayed; or
- Vapour cloud explosion (VCE) if a flash fire occurs within a congested or confined plant area.

With no large areas of congestion or confinement, any explosion overpressure associated with an external release and flash fire would have smaller effect distances compared to the flash fire itself. Acoustic enclosures for compressors may be used at some sites; however the EIS reference case is for compressors in the open [B487]. If enclosures are required, then similar to power generation equipment, the risk of explosion within the enclosures will be managed by implementing measures such as gas detection and automatic shutdown, use of certified equipment and ventilation. Updates to the Qualitative Risk Assessment will review explosion potential if there are enclosures.

Other hazards affecting people and property, but not quantified in the PHA, are discussed in Section 27.3.2.6.

27.5.4 Risk Assessment

From the risk analysis in the PHA, Table 27–4 summarises the minimum separation distances required from facilities to land use types specified by the planning criteria. These should be considered as preliminary since design and equipment layouts are preliminary. These are minimum separation distances; codes, guidelines or other criteria may require additional separation distances.

The well sites and gas gathering system pose a very low risk to offsite land uses, commensurate with their low operating pressures. The largest separation distances are for the CGPF and IPF where the CSG pressure is increased for export. The separation distances in Table 27–4 for these facilities are measured from compression facilities which are the highest risk areas.

The low pressure gas gathering pipelines and medium pressure infield pipelines meet risk criteria at the pipelines due to the relatively low pressure and low likelihood of release and ignition. However suitable easements should be maintained around the pipelines for protection of the pipelines and the public.

With the dispersed population found in the Project area it is possible to develop the area for CSG exploration and operation whilst ensuring safety of people and property. This will be achieved by avoiding towns and maintaining adequate buffer zones based on the separation distances estimated in the PHA between the Project activities and the local population.

Table 27-4 Summary of Separation Distances from Risk Analysis

Facility	Land Use	Separation to Meet Criteria (m)	Measured From	Basis
Well Site	Sensitive	20	Wellhead	NSW government well site separation distance guidelines (DIPNR, 2004) [1]
	Residential	10	Wellhead	NSW government well site separation distance guidelines (DIPNR, 2004) [1]
FCF [2]	Sensitive	140	Compression	Fatality contours
	Sensitive	110	Compression	Heat radiation injury risk contours
	Residential	140	Compression	Fatality contours
	Residential	110	Compression	Heat radiation injury risk contours
	Commercial	120	Compression	Fatality contours
	Active open spaces	110	Compression	Fatality contours
	Industrial sites	70	Compression	Heat radiation property damage risk contour

Facility	Land Use	Separation to Meet Criteria (m)	Measured From	Basis
CGPF [3]	Sensitive	550	Compression	Fatality contours
	Sensitive	350	Compression	Heat radiation injury risk contours
	Residential	500	Compression	Fatality contours
	Residential	350	Compression	Heat radiation injury risk contours
	Commercial	400	Compression	Fatality contours
	Active open spaces	350	Compression	Fatality contours
	Industrial sites	250	Compression	Heat radiation property damage risk contour
Low Pressure Gas Gathering 630 mm pipeline	All	0	Pipeline	Risk at pipeline meets criteria. Suitable easement from pipeline to be maintained
Medium Pressure Infield 400 mm Pipeline	All	0	Pipeline	Risk at pipeline meets criteria. Suitable easement from pipeline to be maintained

1. Well sites meet their risk criteria within site area hazard distances and likelihoods of release are small. Separation distance shown is minimum recommended by government guidelines.

2. FCF basis is 12 compression trains (reflecting an expected maximum capacity of 120 TJ/d FCF).

3. CGPF basis is 21 LP compression trains, 7 HP compression trains (reflecting an expected maximum capacity of 210 TJ/d CGPF). IPF basis is 19 LP compression trains, 7 HP compression trains (reflecting an expected maximum capacity of 190 TJ/d IPF).

27.6 Integrated Risk Management Plan

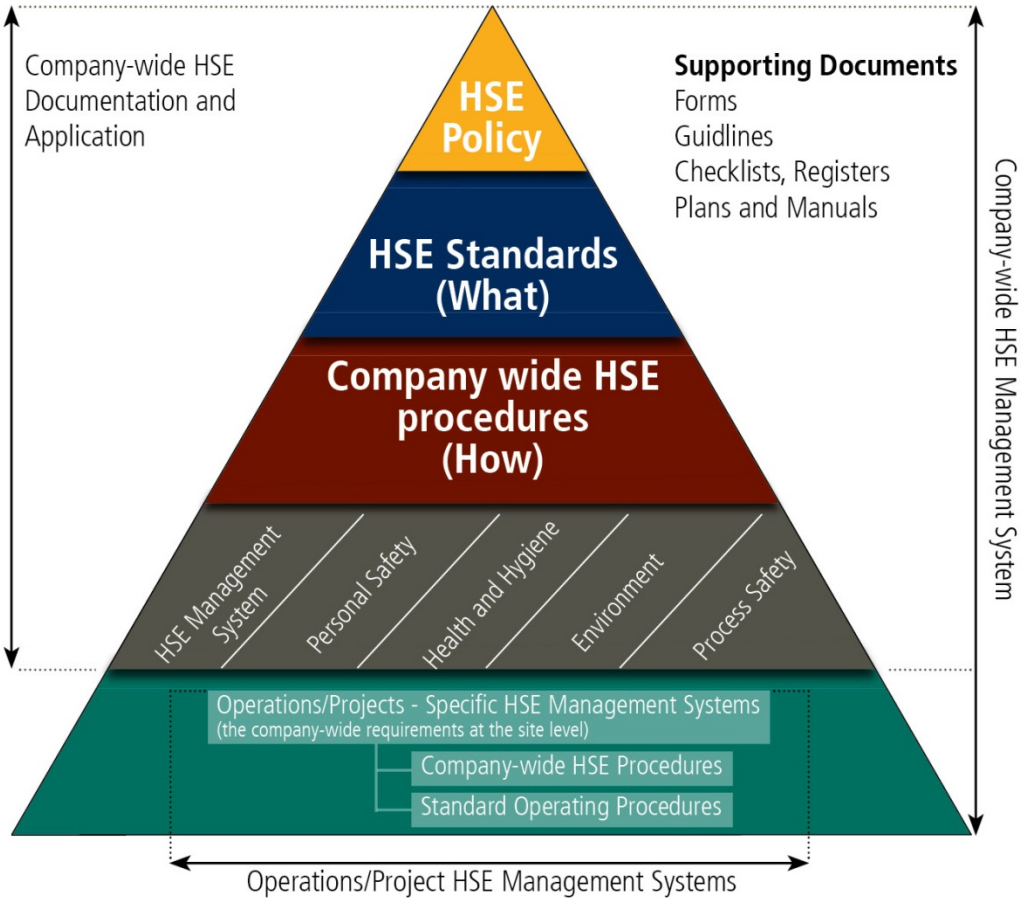
27.6.1 Arrow Health, Safety and Environment Management System Overview

A Project HSEMS will be developed from Arrow's HSEMS [B494]. The Project HSEMS is an integrated risk management plan for health, safety and environment (HSE) for the whole life of the Project, from design and construction, through to operation and decommissioning and will be updated from time to time as required [B473] & [B498]. The Project HSEMS will incorporate the elements of the SMP required under the P&G Act.

As shown by Figure 27–2, the Project HSEMS will use documents from the Arrow HSEMS and contain Project specific requirements that may relate to the local area, prevailing legislation and local environment. The Project HSEMS must comply with the Arrow HSEMS.

Aspects of the Arrow HSEMS that relate to hazard and risk are described in the following sections.

Figure 27-2 Arrow Health, Safety and Environment Management System Document Hierarchy



27.6.2 Management of Natural Events

Management of risk associated with natural events is addressed by the Arrow HSE standard *Natural Events*. This is supplemented by an HSE procedure *Natural Events,* which sets out how the standard is implemented. The standard requires appropriate risk assessments for natural events to manage risks to ALARP. Credible natural events are considered during design and operations to ensure adequate provision and maintenance for:

- Foundation and earthworks design;
- Road, water and overhead lines crossings construction;
- Protection from flooding;
- Provision of fire breaks; and
- Appropriate design for occupied buildings.

The *Natural Events* standard requires that evacuation and/or shelter is included in the design wherever temporary or permanent camps are built in remote locations.

27.6.3 Personal Safety, Health and Hygiene Standards

Apart from road and air safety, the standards and procedures for personal safety address construction safety management and maintenance activities including confined space, electrical safety, lifting, hot work, excavation, safe isolation, working at heights and mobile equipment.

All operations and projects must comply with Arrow's *Journey Management and Driver Safety Procedure* or, for contractors, with an equivalent procedure. This sets minimum requirements for vehicles and journeys. It includes requirements for risk assessment and appropriate controls.

Health and hygiene standards include chemical management, which sets minimum requirements for chemicals and Dangerous Goods. Processes will be established to respond to an emergency or spill involving hazardous chemicals or Dangerous Goods. Design requirements and controls for chemicals and Dangerous Goods are also covered under process safety standards.

27.6.4 Life Saving Rules

In addition to the personal safety standards, Arrow has adopted 12 *Life Saving Rules* that are associated with activities where non-compliance has the highest likelihood to result in death or serious injury [B542]. The rules are:

- Work with a valid work permit when required;
- Conduct gas tests when required;
- Verify isolation before work begins and use the specified life protecting equipment;
- Obtain authorisation before entering a confined space;
- Obtain authorisation before overriding or disabling safety critical equipment;
- Protect yourself against a fall when working at height;
- Do not walk under a suspended load;
- Do not smoke outside designated areas;
- No alcohol or drugs while working or driving;
- While driving, do not use your phone and do not exceed speed limits;
- Wear your seat belt; and
- Follow prescribed Journey Management Plan.

27.6.5 Risk Management

Arrow's framework for asset integrity and process safety has the five elements shown in Figure 27–3. Risk management is one of the elements. While risk management is a major part of the design process, it continues through all phases of a development and provides input into other elements of the asset integrity and process safety framework [B519].

The workflow of risk management from Arrow's risk management procedure is reproduced in Figure 27–4. Under the risk management procedure, process safety hazards must be identified and managed to ALARP. ALARP demonstration can only be made after an extensive risk management process of hazard identification, hazard assessment and identification of critical barriers. The technique of bow-ties is used by Arrow to identify and demonstrate the adequacy of barriers for the prevention and

control or an accident event. The hierarchy of control (Figure 27–5) is used at appropriate stages to determine appropriate means of controlling risks (the barriers).

Hazards are documented in a risk register that includes the potential effects on people, the environment, reputation and assets. The risk register is a living document that is reviewed and updated when new information becomes available or changes to controls or activities occur. The risk register for the Project will continue to be developed from the PHA.

Risk management includes assurance of the competencies and fitness of those persons in HSE critical positions, those undertaking HSE critical activities and of contractors.

A statement of fitness for an asset is required by Arrow management before commissioning a new asset, when modifying an existing asset, when restarting an asset after an incident involving an uncontrolled shutdown, overhaul, turn-around, when an asset has been subjected to conditions outside its operational limits or environmental conditions occur beyond the original design parameters. The statement of fitness must confirm the following:

- Process safety risks have been identified, documented and are managed to ALARP;
- Employees and contractors executing HSE critical activities are competent and fit for work;
- HSE critical equipment meets its technical integrity requirements;
- Modifications are complete and authorised as specified in the Management of Change procedure;
- Design and construction of new assets and modifications to existing assets meet the design and engineering requirements;
- Process Safety Basic Requirements are met; and
- Procedures are in place to operate HSE critical equipment within its operational limits.

Figure 27-3 Arrow Framework for Asset Integrity and Process Safety

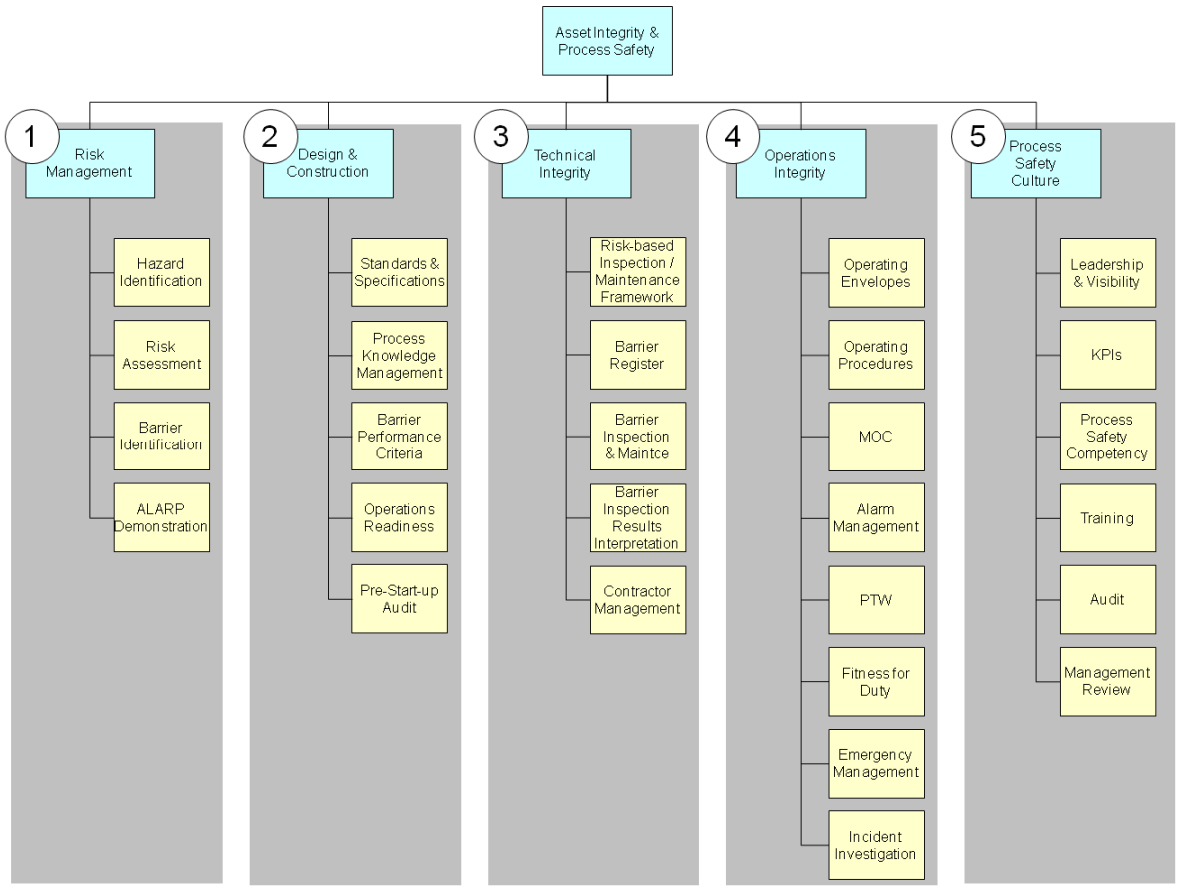


Figure 27-4 Arrow Risk Management Workflow

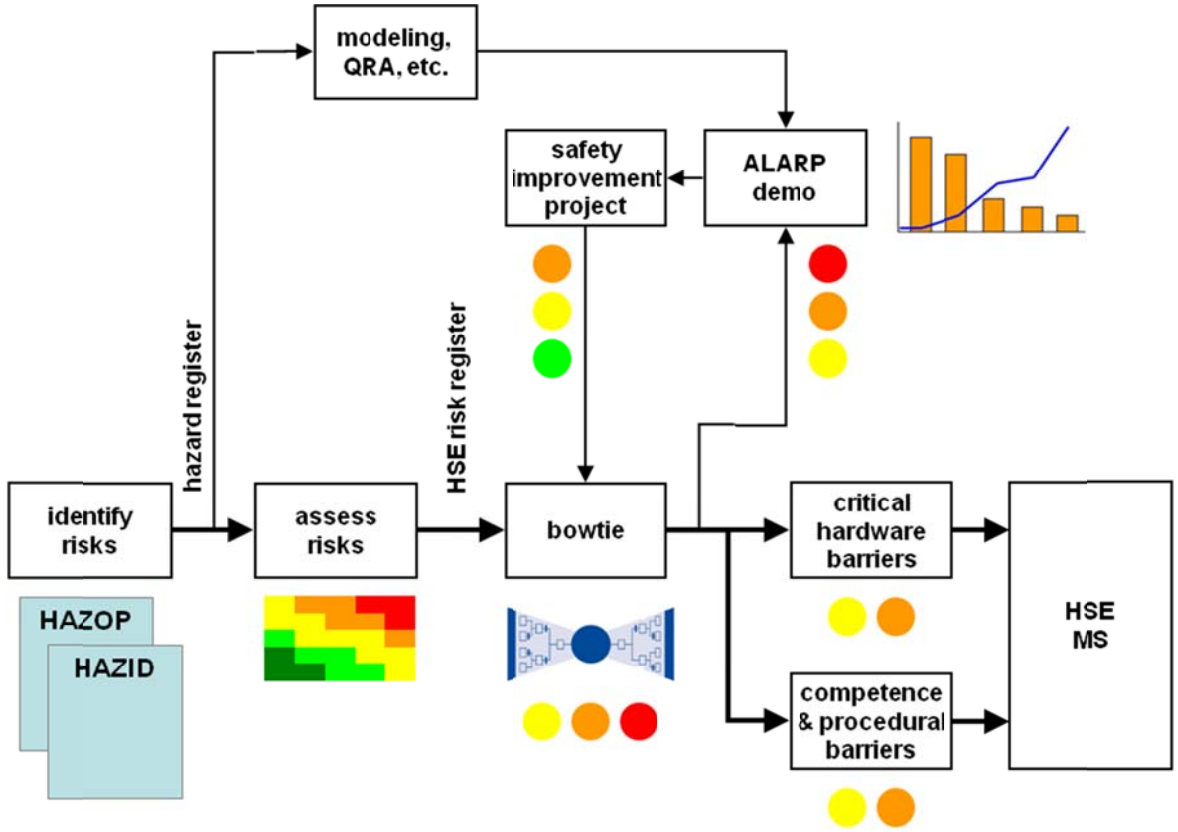
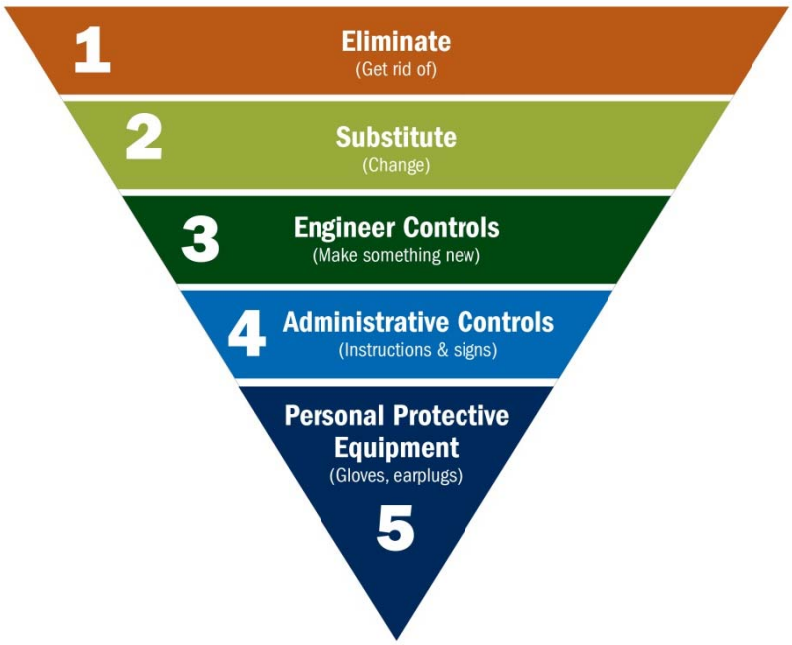


Figure 27-5 Arrow Hierarchy of Control



27.6.6 Process Safety

The Arrow HSEMS includes nine *Process Safety Basic Requirements* that have been developed from historical process safety incidents and which focus on the main causes and key barriers to prevent such incidents. The relevant requirements for the Project are:

- *Safe siting of occupied buildings* - This includes minimum resistance for blast rated buildings and use of appropriate standards for all occupied buildings on facilities where risks are significant;
- *Permit to work*. This includes requirements for independent verification, including effectiveness, of the Permit to Work system;
- *Emergency shutdown valves* - This requires the suitable location of emergency shutdown valves on pipelines so that their exposure to facility incidents is minimised [B505];
- *Management of change* - Management of change systems for process, procedural and organisation changes must be verified for their effectiveness, including by independent HSE audit;
- *Avoid brittle fracture of metallic materials*. The lower design temperature or minimum allowable temperature must be determined and measures taken to prevent exposure or prevent the equipment being exposed to pressure when below the temperature, for example during blowdowns; and
- *Alarm management* - Alarm management systems are compulsory on assets such as the compression facilities where risks are significant.

The other *Process Safety Basic Requirements* are:

- *Avoid liquid release relief to atmosphere*;
- *Avoid tank overfill followed by vapour cloud release*; and
- *Sour Gas (H_2S)*.

Process safety standards also cover:

- Design and construction; and
- Operations, inspection and maintenance.

Requirements for design and construction include process safety reviews which are required for new assets and modifications at least every five years.

27.6.7 Emergency Management

Arrow has established regional emergency response plans across their operations [B480]. The objectives of the plans are to [B513]:

- Detail the logistical support processes for emergency response and recovery, covering staff, shut down, containment, communications and emergency systems;
- Detail the liaison processes with all agencies, including emergency services;
- Protect personnel, environment, facilities, production and the community through the leadership and commitment of the site and company management; and
- Manage the operational relationships across sites and ensure the coordination of the emergency response plan.

Regional response plans for the Project area will be developed and updated as operations in the area expand to include Project specific information. Arrow already has plans in place for their existing operations in Queensland. The plans are developed in consultation with emergency services organisation and include the following parts:

- Incident guides;
- First aid guide;
- Contact information;
- Forms;
- Site(s) information;
- Emergency controller;
- Emergency response team;
- Response termination;
- Emergency response policy; and
- Plan administration.

Arrow will maintain a 24 hour emergency hotline and rostered emergency controllers. The emergency controller will activate the emergency plan and oversee emergency response. Other members of the emergency response team who may be called upon include:

- Forward commander, who will attend the scene;
- Emergency Response Plan Administrator;
- Communications officer;
- Records officer, who manages recording of information about the incident;
- Safety officer, who ensures safety of incident response and commences incident investigation; and
- Welfare officer.

Arrow personnel and contractors are trained in their applicable emergency response procedures and regular training exercises are undertaken which include the involvement of local emergency services.

27.6.8 Performance Monitoring and Auditing

Across all its operations, Arrow believes nothing less than zero harm is acceptable. HSE performance monitoring, measurement and reporting is a key process to help achieve this objective. The Project HSEMS will detail the requirements for monitoring, measurement and reporting of HSE performance, including:

- Objectives;
- Lead and lag key performance indicators;
- Audits, reviews and self-assessments;
- Compliance with legislation;
- Corrective actions closeout;
- Contractor reporting; and
- Reporting to external stakeholders.

Under Arrow's HSEMS, each project must comply with Arrow's audit and inspection procedure, and each department with field operations and HSE risks must maintain an HSE assurance process. HSE audits are planned and performed using a risk based approach under a process that ensures the competency and accreditation of auditors. An action tracking system is used to ensure that audit findings are completed and verified as effective.